(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number : **0 686 905 A1**

(12) EUROPEAN PATENT APPLICATION

(21) Application number : **95303533.4**

(51) Int. Cl.[6] : **G06F 1/00**

(22) Date of filing : **24.05.95**

(30) Priority : **03.06.94 US 253802**

(43) Date of publication of application :
13.12.95 Bulletin 95/50

(84) Designated Contracting States :
DE FR GB NL SE

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(54) Method and apparatus for secure remote authentication in a public network

(57) A client workstation provides a login address as an anonymous ftp (file transfer protocol) request, and a password as a user's e-mail address. A destination server compares the user's e-mail address provided as a password to a list of authorized users' addresses. If the user's e-mail address is located on the list of authorized users' addresses maintained by the destination server, the destination server generates a random number (X), and encrypts the random number in an ASCII representation using encryption techniques provided by the Internet Privacy Enhanced Mail (PEM) procedures. The encrypted random number is stored in a file as the user's anonymous directory. The server further establishes the encrypted random number as one-time password for the user. The client workstation initiates an ftp request to obtain the encrypted PEM random number as a file transfer (ftp) request from the destination server. The destination server then sends the PEM encrypted password random number, as an ftp file, over the Internet to the client workstation. The client workstation decrypts the PEM encrypted file utilizing the user's private RSA key, in accordance with established PEM decryption techniques. The client workstation then provides the destination server with the decrypted random number password, which is sent in the clear over the Internet, to login to the destination server. Upon receipt of the decrypted random number password, the destination server permits the user to login to the anonymous directory, thereby completing the user authentication procedure and accomplishing login.

FIG. 3

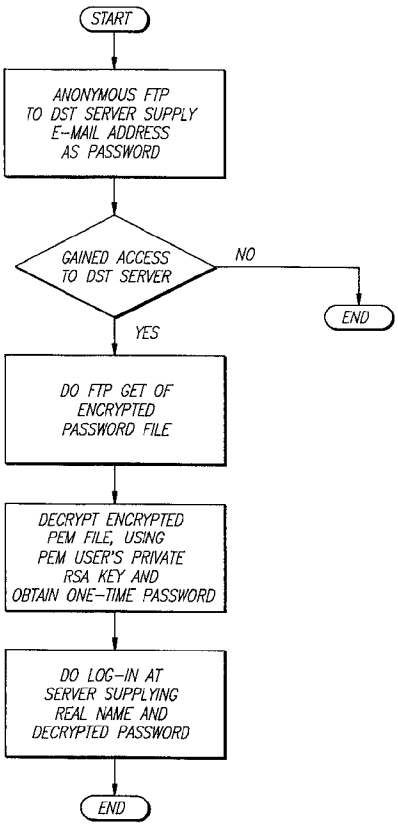

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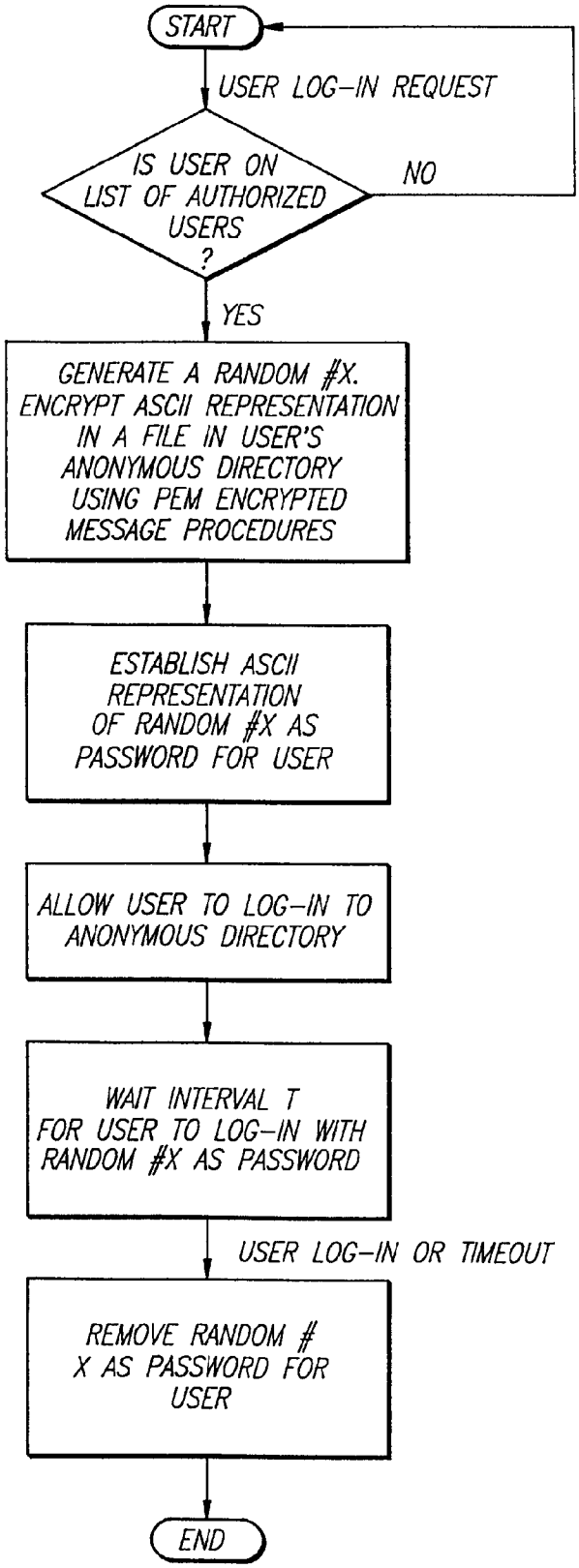
FIG. 4


START
USER LOG-IN REQUEST
IS USER ON LIST OF AUTHORIZED USERS ?
NO
YES
GENERATE A RANDOM #X. ENCRYPT ASCII REPRESENTATION IN A FILE IN USER'S ANONYMOUS DIRECTORY USING PEM ENCRYPTED MESSAGE PROCEDURES
ESTABLISH ASCII REPRESENTATION OF RANDOM #X AS PASSWORD FOR USER
ALLOW USER TO LOG-IN TO ANONYMOUS DIRECTORY
WAIT INTERVAL T FOR USER TO LOG-IN WITH RANDOM #X AS PASSWORD
USER LOG-IN OR TIMEOUT
REMOVE RANDOM # X AS PASSWORD FOR USER
END

BACKGROUND OF THE INVENTION

1. Field of the Invention:

The present invention relates to methods and apparatus for providing remote user authentication in a public network. More particularly, the present invention provides methods and apparatus for remote authentication using a one-time password scheme having a secure out-of-band channel for initial password delivery.

2. Art Background:

Over the past few years, the networking of computers for electronic mail ("e-mail") communication and data transfer has grown from simple local area networks to a global network referred to as the "Internet". The Internet comprises a spiderweb of networks which criss-cross the globe and permit users to send and receive e-mail messages, transfer data and access remote data bases between computers coupled to servers. In addition to fixed positions on the Internet, computer systems, such as for example, lap top computers, may be physically moved from one location on the network to another. Wireless links coupling the computers to the Internet, such as direct satellite links, also permit users to access the Internet from remote areas.

As the number of users on the Internet has grown, so have concerns regarding network security. Many businesses and government organizations utilize the Internet for the transfer of business information, government project data and other information which may be considered confidential. Due to the size and complexity of the Internet, the opportunity for an intruder to intercept messages and gain access to confidential information has become a significant concern. The Internet community has established message encryption and authentication procedures for Internet electronic mail. These encryption and authentication procedures are known as privacy enhanced mail (PEM). The PEM protocol establishes procedures to provide for enhanced privacy in e-mail services over the Internet. The PEM protocol is intended to be compatible with a wide range of key management approaches including symmetric (secret key) and asymmetric (public key) approaches for the encryption of data encrypting keys. Privacy enhanced mail services assure message integrity, and are offered through the use of end-to-end cryptography between originator and recipient processes at or above the user level. No special processing requirements are imposed on the message transfer system at endpoints, or at intermediate relay sites on the Internet. The reader is referred to the PEM RFC documents filed concurrent with the application on which this patent is based, and incorporated herein by reference, entitled: "Privacy Enhancement for Internet Electronic Mail", Parts I-IV, RFCS 1421-1424, available on the Internet at /home/internet/rfcs on files rfc1421-rfc1424 (hereinafter at times referred to as "PEM Protocols").

However, although privacy enhanced mail service is available on the Internet, all current applications on the Internet (commonly referred to as "legacy" applications), such as Telnet, File Transfer Protocol ("ftp"), and the like, use simple authentication having reusable passwords. Although it is generally understood that strong authentication using cryptotechniques would provide enhanced password security on the Internet, retrofitting the existing installed base of network applications with such a strong authentication mechanism would take some period of time. In the interim, an intruder can monitor the network and intercept passwords transmitted over the Internet. Since all passwords are currently transmitted from user to a remote server in unencrypted ("clear") form, Internet users are vulnerable to an intruder determining their password, and later logging on to a server utilizing the stolen password of a legitimate user. In fact, there have been cases where intruders have tapped the Internet at well known public sites and have accumulated literally thousands of legitimate valid passwords. Thus, the Internet must be viewed as a large insecure channel in which passwords are transmitted in the clear, and may be acquired by unauthorized parties.

As will be described, the present invention provides methods and apparatus to permit an Internet user to acquire a password which is good for only a one time use. Through the use of the existing privacy enhanced mail system on the Internet, the present invention ensures that only the legitimate user can gain access to the password. Moreover, as will be described, the present invention does not require the retrofitting of existing applications and computers with a strong authentication mechanism.

Summary of the Invention

The present invention provides an improved method and apparatus for user authentication in a network environment between a client computer ("workstation") and a remote destination server coupled to a network. A user operating the client workstation provides a login address as an anonymous ftp (file transfer protocol) request, and a password as the user's e-mail address. The destination server compares the user's e-mail address provided as a password to a list of authorized users' addresses. If the user e-mail address provided is not on the destination server's list of authorized user addresses, then the user login request is automatically denied. If the user's e-mail address is located on the list of authorized users' addresses maintained by the destination

server, the destination server generates a random number (X), and encrypts the random number in an ASCII representation using encryption techniques provided by the Internet Privacy Enhanced Mail (PEM) message and encryption authentication procedures. The encrypted random number is stored in a file as the user's anonymous directory. The server further establishes the encrypted ASCII representation of the random number as one-time password for the user. The client workstation initiates an ftp request to obtain the encrypted PEM random number as a file transfer (ftp) request from the destination server. The destination server then sends the PEM encrypted password random number, as an ftp file, over the Internet to the client workstation. The client workstation decrypts the PEM encrypted file utilizing the user's private RSA key, in accordance with established PEM decryption techniques. The client workstation then provides the destination server with the decrypted random number password, which is sent in the clear over the Internet, to login to the destination server. Upon receipt of the decrypted random number password, the destination server permits the user to login to the anonymous directory, thereby completing the user authentication procedure and accomplishing login. The destination server removes the random number password from its anonymous directory, such that any future login attempts requires a new random number password. Additionally, the destination server deems the random number password valid only for a predetermined time period (t), such that any delay beyond the time period (t) in accomplishing the login by the client workstation results in a timeout, and invalidation of the random number password. In the event of a timeout, the user must obtain a new random number password from the destination server in accordance with the method of the present invention.

Brief Description of the Drawings

Figure 1 illustrates a work station used to communicate with other workstations over a network and incorporating the teachings of the present invention.

Figure 2 conceptually illustrates the Internet network.

Figure 3 is a flow chart illustrating the sequence of steps executed by a user's workstation of the type illustrated in **Figure 1**.

Figure 4 is a flow chart illustrating the sequence of steps for the present invention's privacy enhanced mail based user authentication system, executed by a server data processing device.

Figure 5 is a diagrammatical illustration of the data paths utilized by the present invention for providing an encrypted password using privacy enhanced mail, and the use of the decrypted password sent over the Internet in accordance with the teachings of the present invention to accomplish login.

Notation and Nomenclature

The detailed descriptions which follow are presented largely in terms of symbolic representations of operations of data processing devices coupled to a network. These process descriptions and representations are the means used by those skilled in the data processing arts to most effectively convey the substance of their work to others skilled in the art.

An algorithm is here, and generally, conceived to be a self-consistent sequence of steps leading to a desired result. These steps are those requiring physical manipulations of physical quantities. Usually, though not necessarily, these quantities may take the form of electrical or magnetic signals capable of being stored, transferred, combined, compared, displayed and otherwise manipulated. It proves convenient at times, principally for reasons of common usage, to refer to these signals as bits, values, elements, symbols, operations, messages, terms, numbers, or the like. It should be borne in mind, however, that all of these similar terms are to be associated with the appropriate physical quantities and are merely convenient labels applied to these quantities.

In the present invention, the operations referred to are machine operations. Useful machines for performing the operations of the present invention include general purpose digital computers (referred herein as "workstations"), or other similar devices. In all cases, the reader is advised to keep in mind the distinction between the method operations of operating a computer and the method of computation itself. The present invention relates to method steps for operating a computer, coupled to a series of networks, and processing electrical or other physical signals to generate other desired physical signals.

The present invention also relates to apparatus for performing these operations. This apparatus may be specially constructed for the required purposes or it may comprise a general purpose computer selectively activated or reconfigured by a computer program stored in the computer. The method/process steps presented herein are not inherently related to any particular computer or other apparatus. Various general purpose machines may be used with programs in accordance with the teachings herein, or it may prove more convenient to construct specialized apparatus to perform the required method steps. The required structure for a variety of these machines will be apparent from the description given below.

Detailed Description of the Invention

In the following description, numerous details are set forth such as workstation system configurations, representative messages, servers, etc., to provide a thorough understanding of the present invention. However, it will be apparent to one skilled in the art

that the present invention may be practiced without these specific details. In other instances, well known circuits and structures are not described in detail in order to not obscure the present invention. Moreover, certain terms such as "knows", "sends", "receives", "verifies", "examines", "finds", "determines", "authenticates", etc., are used in this Specification and are considered to be terms of art. The use of these terms, which to a casual reader may be considered personifications of computer or electronic systems, refers, for simplicity, to the functions of the system as having human-like attributes. For example, a reference herein to an electronic system as "determining" something is simply a shorthand method of describing that the electronic system has been programmed or otherwise modified in accordance with the teachings herein. The reader is cautioned not to confuse the functions described with everyday human attributes. These functions are machine functions in every sense.

Figure 1 illustrates a data processing system (hereinafter a "workstation") in accordance with the teachings of the present invention. The workstation includes a computer **10** which comprises three major components. The first of these is an input/output (I/O) circuit **12** which is used to communicate information in appropriately structured form to and from other portions of the computer **10**. In addition, computer **10** includes a central processing unit (CPU) **13** coupled to the I/O circuit **12** and a memory **14**. These elements are those typically found in most general purpose computers and, in fact, computer **10** is intended to be representative of a broad category of data processing devices. Also shown in **Figure 1** is a keyboard **15** to input data and commands into computer **10**, as is well known. A network interface circuit **17** is also coupled to the computer **10** through I/O circuit **12**, to permit the computer **10** to communicate with other workstations and servers over a network, such as for example, the Internet. A raster display monitor **16** is shown coupled to the I/O circuit **12** and is used to display images generated by CPU **13** in accordance with the present invention. Any well known variety of cathode ray tube (CRT) or other type of display may be utilized as display **16**.

Referring now to **Figure 2**, the Internet may be conceptually described as an open network generally referred to in the figure by the numeral **20**, to which numerous servers **22**, **24**, **26** and **28** are coupled. Each of the respective servers is coupled to workstations **29**, **31**, **33** and **35**, as shown. It will be appreciated that **Figure 2** is described for illustration purposes only, and that in reality the Internet includes many tens of thousands of servers and work stations. Additionally, although the Internet is illustrated in **Figure 2** as a single network, it will be appreciated that the Internet is actually a series of networks forming a spiderweb-like topology spanning virtually every continent in the world. As is well known, a user operating a workstation in, for example, Singapore, may send messages, access data and databases and execute a variety of functions over the Internet to, for example, a workstation located in Mountain View, California.

In the operation of many networks, and in particular, the Internet, a user operating for example workstation **29**, referred to as the "client workstation", may wish to access a workstation **33** which, as illustrated, is coupled to the server **26**. The server **26** is referred to in the industry as the "destination server" and the combination of client workstation **29** and server **26** is known as the "client-server". Generally, in order for client workstation **29** to access destination server **26** and data which may be disposed at the server **26**, or alternatively, at a workstation **33**, it is necessary for the client workstation **29** to provide a password to the server **26**. However, as previously noted, passwords are sent over the Internet **20** in "the clear" thereby giving intruders access to unencrypted passwords. Additionally, passwords are relatively easy to guess given a sufficiently powerful workstation eavesdropping at a node on the Internet. Once an unencrypted password has been captured by an intruder the intruder may then access the network devices as an authorized user. Thus, the sending of passwords in the clear over the Internet provides an opportunity for a would be intruder to gain access to an authorized user's password, and thereby compromises network security.

In accordance with the teachings of the present invention, assume for sake of example, that a client workstation **29** desires to access a destination server **26** coupled to the Internet **20**. In order to access the destination server **26** it is necessary for the client workstation **29** to login on the server **26**. The login by the client workstation **29** to server **26** is an authenticated login in accordance with the teachings of the invention. Traditionally, the client workstation **29** would simply provide a password to the destination server **26** in the clear over the Internet **20**. However, for the reasons previously described, the sending of a password in the clear compromises network security and provides an unacceptable opportunity for intrusion by third parties. One of the characteristics of the present invention is that its methodology operates in conjunction with existing network applications. As previously described, one of the existing network applications on the Internet is privacy enhancement for Internet electronic mail (PEM). Each of the servers (in **Figure 1** servers **22**, **24**, **26** and **28**) coupled to the Internet **20** includes PEM, as does each of the workstations 29, 31, 33 and 35. Generally, PEM is designed to receive a user name (e-mail address) and to fetch its corresponding public key certificate. In general, PEM provides public key cryptography for electronic mail messages, and security for the mail message itself,

as opposed to the authentication of an authorized user. The detailed operation of privacy enhanced mail will not be described in this Specification, since it is well established and currently functioning on the Internet. The reader is referred to the Internet documents, incorporated by reference herein, entitled "Privacy Enhancement for Internet Electronic Mail", parts I-IV, (RFC 14.21 workstation **40** electronic mail name to its list of authorized users. If the user's electronic mail name (in the present example, client workstation **40**) is not on the list of authorized users, the client login request is rejected.

If the identified user is on the list of authorized users, then, as illustrated in **Figure 4**, the destination server 42 generates a random number (X) which will be used as a one-time password. An ASCII representation of the random number is encrypted using the PEM algorithm, and is placed in a file in the user's anonymous directory using PEM encrypted message procedures. As shown in **Figure 4**, the destination server **42** establishes the encrypted ASCII representation of the random number X as the one-time password for the user.

It will be appreciated that the encrypted random number password is addressed only to the user operating workstation **40**. Only the authorized user operating workstation **40** can decrypt the encrypted random number password. As illustrated in the flowchart of **Figure 3**, the client workstation **40** does an ftp to obtain the encrypted PEM random number password from the destination server **42**. The destination server **42** sends the encrypted PEM random number password to the workstation **40** over the Internet **20**. Although an intruder can detect the encrypted random number password over the Internet **20**, only the authorized user of workstation **40** can decrypt the random number password in accordance with the teachings of PEM. The workstation **40**, using the PEM decryption methodology, decrypts the encrypted PEM file using the PEM users private RSA key.

The reader is referred to the document, incorporated by reference herein, by Fahn, "Answers to Frequently Asked Questions about Today's Cryptography" (RSA Laboratories, 1992), submitted concurrent with the filing of the application on which this patent is based, and other references submitted, for a detailed description of RSA technology. Since the RSA technology is well known, it will not be described further herein.

As shown in the flowchart of **Figure 3**, once the PEM encrypted random number password is decrypted by the client workstation **40** using its private key, the decrypted password is then supplied over the Internet **20** to the destination server **42** for login. For the actual login by the client workstation **40** to the destination server **42**, the decrypted random number password is sent in the clear over the Internet **20** along with the user's e-mail address name.

As shown in **Figure 4,** the destination server **42** permits the user to login to the anonymous directory utilizing the one-time random number password within a predetermined time (t). Providing a predetermined time window in which to permit the client workstation **40** to login to the destination server **42**, provides additional security. In the event the time period (t) expires without the workstation **40** logging into the destination server **42** utilizing the decrypted random number password, then a time out occurs and the random number password is deemed invalid. In such event, it is necessary for the user operating the client workstation **40** to acquire a new random number password utilizing the teachings described in this Specification with reference to **Figures 3** and **4**. Assuming that the user provides the decrypted random number password to the destination server **42** within the time interval (t), the destination server **42** permits the login and the user authentication process is completed. The destination server **42** then removes the random number X as a password for the user, thereby requiring any future logins by the workstation **40** to first obtain a new random number password. Thus, each login between a client and a server over the Internet requires a new password.

It will be appreciated that since the decrypted random number password provided by the client workstation **40** to the destination server **42** over the Internet **20** is sent in the clear, an intruder can detect this password during the login process. However, since the server **42** invalidates or removes the random number password after each successful login, or alternatively, after the time out of the interval (t), network security is not compromised. Even assuming an intruder intercepts the decrypted random number password over Internet **20**, it is of no use to the intruder since it is only valid for a single login, and the login must occur during the predetermined time (t).

Accordingly, a system and method for user authentication in a public network is disclosed. While the present invention has been described in conjunction with a few specific embodiments identified in **Figures 1-5**, it will be apparent to those skilled in the art that many alternatives, modifications and variations in light of the foregoing description are possible. For example, although the present invention has been described with reference to user authentication in the Internet environment, it will be appreciated that the teachings of the present invention may be applied to any public or private network topology.

Claims

1. A method for user authentication between a first computer and a second computer, comprising the steps of:

providing an element for performing the

step of said first computer providing a first request to said second computer, said first request including a user identification code identifying a user of said first computer;

providing an element for performing the step of said second computer receiving said first request and determining if said user identification code of said user is authorized, such that if said user identification code is authorized said second computer:

generates a first random number;

stores said first random number as a one time password;

encrypts said first random number used as said one time password;

providing an element for performing the step of said second computer providing said encrypted one time password to said first computer;

providing an element for performing the step of said first computer decrypting said one time password and providing said decrypted one time password to said second computer;

providing an element for performing the step of said second computer comparing said received decrypted one time password to said stored one time password, such that if said received and stored one time passwords match said user is authenticated.

2. The method as defined by Claim 1 wherein said first computer provides a second request to said second computer to obtain said encrypted one time password, said second computer upon receipt of said second request provides said encrypted one time password to said first computer.

3. The method as defined by Claim 2 wherein said first and second computers are coupled for communication with one another over a network.

4. The method as defined by Claim 3 wherein said second computer stores said first random number as said one time password for a predetermined time (t), such that if said second computer does not receive said decrypted one time password within said time (t) from said first computer, said first random number is invalidated as said one time password by said second computer and is unusable.

5. The method as defined by Claim 4 wherein any subsequent authentication of said user requires the generation of a new random number to be used as said one time password.

6. The method as defined by Claim 5 wherein said second computer encrypts said first random number using PEM encryption.

7. The method as defined by Claim 6 wherein said first computer decrypts said one time password using PEM decryption.

8. The method as defined by Claim 7 wherein said network comprises the Internet.

9. The method as defined by Claim 8 wherein said first request further includes an anonymous ftp request as a login.

10. The method as defined by Claim 9 wherein said second request comprises an anonymous ftp request to obtain said encrypted one time password from said second computer.

11. A system for user authentication between a first computer and a second computer, comprising:

a receiving element coupled to said first computer for providing a first request to said second computer, said first request including a user identification code identifying a user of said first computer;

an element coupled to said second computer for receiving said first request and determining if said user identification code of said user is authorized, such that if said user identification code is authorized said second computer:

generates a first random number;

stores said first random number as a one time password;

encrypts said first random number used as said one time password;

said second computer including a transmission element for providing said encrypted one time password to said first computer;

said first computer including a decrypting element for decrypting said one time password and providing said decrypted one time password to said second computer;

said second computer comparing said received decrypted one time password to said stored one time password, such that if said received and stored one time passwords match said user is authenticated.

12. The system as defined by Claim 11 wherein said first computer provides a second request to said second computer to obtain said encrypted one time password, said second computer upon receipt of said second request provides said encrypted one time password to said first computer.

13. The system as defined by Claim 12 wherein said first and second computers are coupled for communication between each other over a network.

14. The system as defined by Claim 13 wherein said

second computer stores said first random number as said one time password for a predetermined time (t), such that if said second computer does not receive said decrypted one time password within said time (t) from said first computer, said first random number is invalidated as said one time password by said second computer and is unusable.

15. The system as defined by Claim 14 wherein any subsequent authentication of said user requires the generation of a new random number to be used as said one time password.

16. The system as defined by Claim 15 wherein said second computer encrypts said first random number using PEM encryption.

17. The system as defined by Claim 16 wherein said first computer decrypts said one time password using PEM decryption.

18. The system as defined by Claim 17 wherein said network comprises the Internet.

19. The system as defined by Claim 18 wherein said first request further includes an anonymous ftp request as a login.

20. The system as defined by Claim 19 wherein said second request comprises an anonymous ftp request to obtain said encrypted one time password from said second computer.

FIG. 1

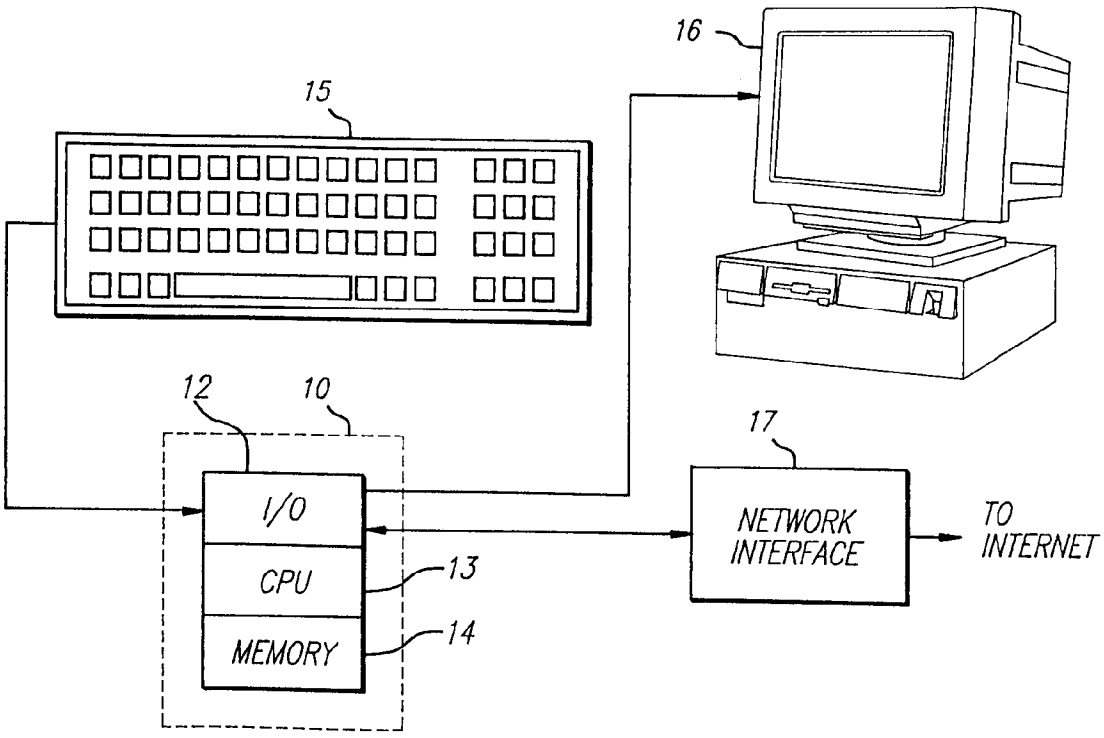

16
15
12
10
17
I/O
CPU
MEMORY
13
14
NETWORK INTERFACE
TO INTERNET

FIG. 2

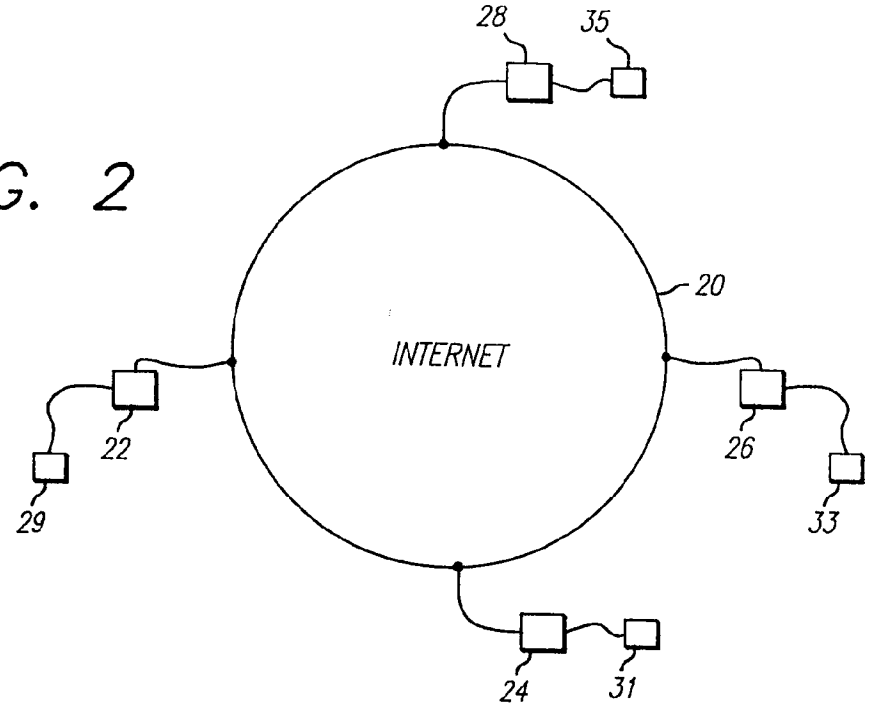

28
35
20
INTERNET
22
29
26
33
24
31

FIG. 3

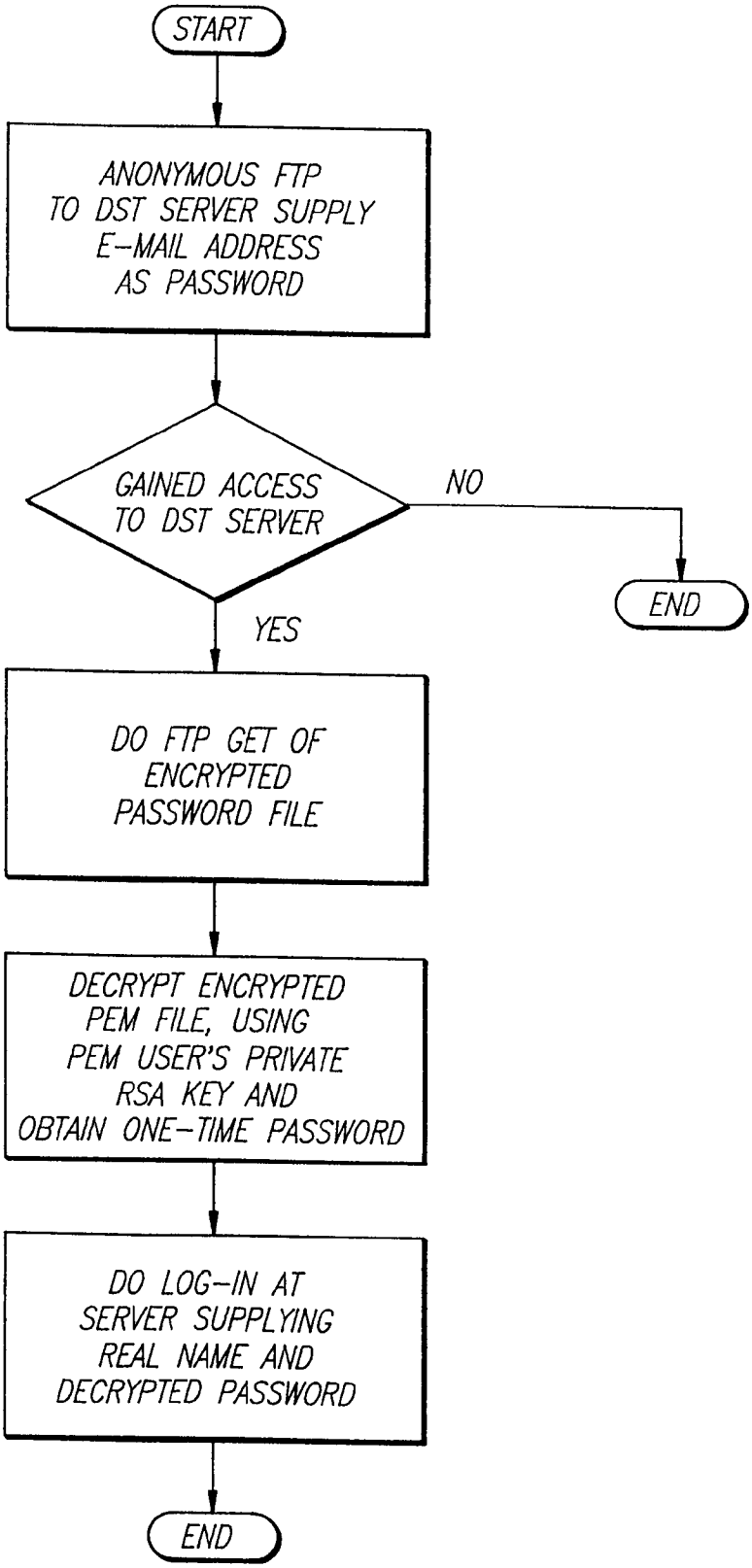
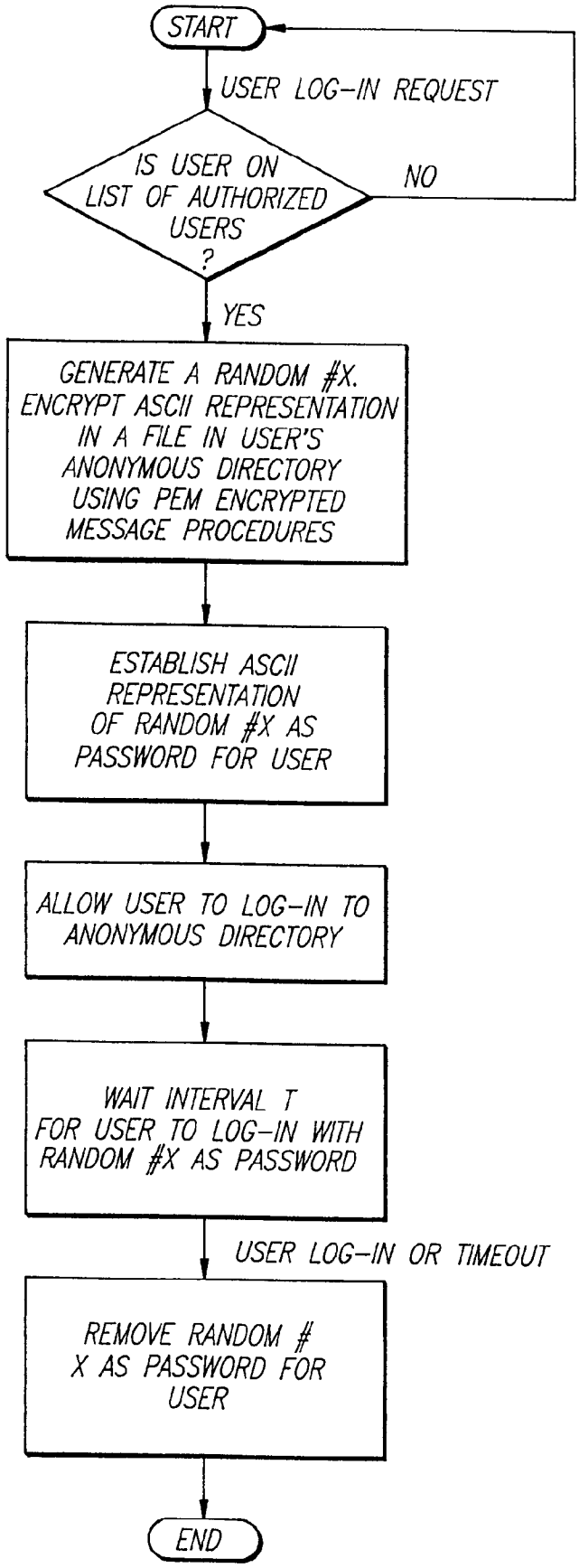

START
ANONYMOUS FTP TO DST SERVER SUPPLY E-MAIL ADDRESS AS PASSWORD
GAINED ACCESS TO DST SERVER
NO
END
YES
DO FTP GET OF ENCRYPTED PASSWORD FILE
DECRYPT ENCRYPTED PEM FILE, USING PEM USER'S PRIVATE RSA KEY AND OBTAIN ONE-TIME PASSWORD
DO LOG-IN AT SERVER SUPPLYING REAL NAME AND DECRYPTED PASSWORD
END

FIG. 4


START
USER LOG-IN REQUEST
IS USER ON LIST OF AUTHORIZED USERS ?
NO
YES
GENERATE A RANDOM #X. ENCRYPT ASCII REPRESENTATION IN A FILE IN USER'S ANONYMOUS DIRECTORY USING PEM ENCRYPTED MESSAGE PROCEDURES
ESTABLISH ASCII REPRESENTATION OF RANDOM #X AS PASSWORD FOR USER
ALLOW USER TO LOG-IN TO ANONYMOUS DIRECTORY
WAIT INTERVAL T FOR USER TO LOG-IN WITH RANDOM #X AS PASSWORD
USER LOG-IN OR TIMEOUT
REMOVE RANDOM # X AS PASSWORD FOR USER
END

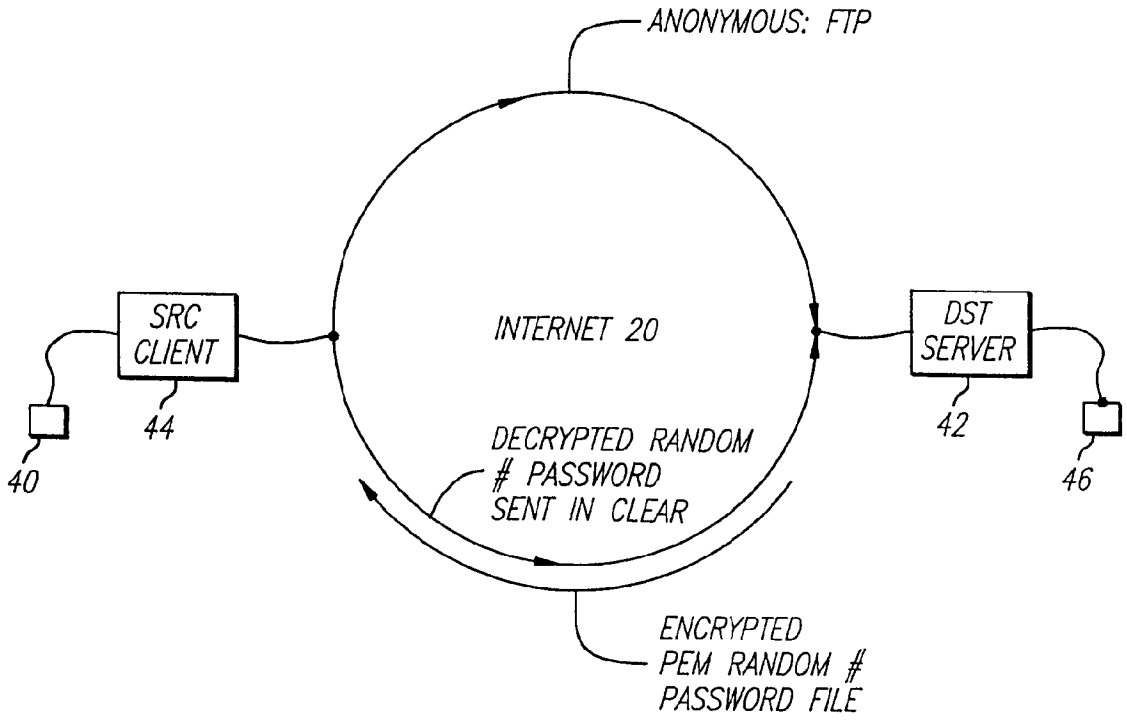

ANONYMOUS: FTP
SRC CLIENT
INTERNET 20
DST SERVER
40
44
42
46
DECRYPTED RANDOM # PASSWORD SENT IN CLEAR
ENCRYPTED PEM RANDOM # PASSWORD FILE

FIG. 5

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 95 30 3533

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
Y	US-A-5 056 140 (KIMBELL) * abstract; figures 1,2 * * column 2, line 14 - column 4, line 65 *	1-20	G06F1/00
Y	GB-A-2 168 831 (STEEBEK SYSTEMS) * page 2, left column, line 2 - line 46 *	1-20	
D,A	J.LINN 'Privacy Enhancement for Internet Electronic Mail, Part I: Message Encryption and Authentication Procedures, RFCS 1421' February 1993 , INTERNET /HOME/INTERNET/RFCS/RFC1421 * the whole document *	3,6-8, 13,16-18	

TECHNICAL FIELDS SEARCHED (Int.Cl.6)

G06F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	29 September 1995	Powell, D

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

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EPO FORM 1503 03.82 (P04C01)